Spring 1962

Behavior of Prairie Plants During Winter Months

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BEHAVIOR OF PRAIRIE PLANTS

DURING WINTER MONTHS

being

A thesis presented to the Graduate Faculty

of Fort Hays Kansas State College in

partial fulfillment of the requirements for

the Degree of Master of Science

by

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THESIS ABSTRACT

Singh, R. P. 1962. Behavior of prairie forbs during winter months.

The principle purpose of this study was to classify and describe the rosettes of some prairie forbs.

Twenty five different species of forbs were studied in the college pasture about two and one-half miles west of Hays, Kansas. Observations were taken on appearance, growth and development and condition in which plants spent winter season. Characteristics such as pubescence, leaf shape and color pattern of leaves were also included.

Rosettes have been defined as a cluster of green leaves occurring on any part of the old plant body during winter months. According to the position of rosettes in relation to the old plant three types of rosettes were recognized namely, basal, stem, and terminal.

Out of the 25 prairie forbs studied, 18 were found having some type of rosette form of growth. Eleven had basal, four had terminal and three had stem rosettes. The rest of the seven forbs possessed either crown buds or rhizomes.

Rosettes, in general, varied considerably in their size and shape, and many rosette leaves were completely different from leaves found on the plant during the growing season. Most of the leaves were pubescent.

ACKNOWLEDGEMENT

The author wishes to express his deep appreciation to Dr. G. W. Tomanek, Chairman, Division of Biological Sciences, for suggesting the problem, for his valuable guidance throughout the investigation, and for reading and criticizing the manuscript. Thanks are also extended to the members of my graduate committee, Drs. F. E. Kinsinger, W. Sims, and Joel Moss for reading and criticizing the manuscript.

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INTRODUCTION

The mixed prairie of Western Kansas is composed of both mid and short grasses but also includes many forbs (Weaver and Albertson, 1956). Forbs are often the same species as those of the True Prairie but the societies or groups of forbs are smaller, fewer, and the individuals less densely aggregated than in True Prairie. Forbs are always present in the Mixed Prairie and although some are rare, others occur quite abundantly. Most species are Compositae and Leguminosae, but many other plant families are also represented. Most legumes are especially valuable as forage, although a few are poisonous. Forbs provide a valuable variety in the diet of livestock and forbs are especially rich in calcium and phosphorus. The cattle do better on mixed herbage than on grasses alone (Costello, 1942). Forbs, in conjunction with various kinds of grasses, have long been employed as indicators of the degree of severity of grazing.

Succession of the seasons and the resulting changes in plants are familiar to everyone. Even in the tropics there are but few localities in which seasonal changes in weather and in plants do not occur. Changes in form and appearance and in relative abundance of different species that occur from season to season, may be found in lawns, pastures, cultivated fields and forests. Great differences in the behavior of individual species are found so that few generalizations apply equally to all kinds of plants.

Inumerable flowers bloom at each season, giving life, and variety to the background of the Mixed Prairie. What do these plants which grow and

bloom so vigorously during spring, summer and fall do during winter? The gradual lowering of temperature and decrease in the length of daily light period lead not only to pigment changes and leaf fall, but to the death of many plants that started from seed the preceeding spring. Some parts of plants, however, remain alive and dormant throughout the late summer, autumn, and winter. The part or parts that remain alive and dormant vary greatly with the kind of plants. The dormant organ of annuals is seed. Seeds of some annuals, however, may also germinate in the autumn; the plants pass the winter in the vegetative condition and bear seed the following spring.

During the life cycle of many biennials, the first season of growth ends with the formation of thickened roots, a short stem and a rosette of leaves near the soil surface. The young plants remain dormant during the winter and in the second growing season complete their life cycle by the development of upright stems, flowers, fruits, and seeds.

The annual active period of growth of perennial forbs is followed by a dormant one in winter when most of the living plant is underground, with no living parts extending much above the soil surface. Some plants have winter rosettes of leaves, others have very short lateral branches with small leaves, and still others have large buds underground. Some perennials may continue living indefinitely.

Since a knowledge of plant behavior during winter months is limited and because no effort has been made to study this behavior more closely and scientifically, it was, therefore, deemed desirable to study this problem. The present study was concerned primarily with the condition in which some mixed prairie forbs spend winter.

The average field man is unable to recognize and classify forbs during winter months. Gathering and organizing of descriptive data concerning plants rosettes may serve as an aid in the identification of forbs in winter. Therefore, an attempt has been made to classify different types of rosettes and give a general description of some important species.

CLIMATE AND VEGETATION

The climate of the area under study is semi-arid. Annual precipitation and temperatures are extremely variable. The normal precipitation is about 23 inches annually, but extremes have ranged from 43.34 inches in 1951 to 9.21 inches in 1956. Most of the rainfall occurs in the early spring and fall of the year.

Winter temperatures are mild but the daily temperatures may be less than 10° F. for several days during the whole winter season. The winter of 1961-62 had temperatures as low as -15° F. and many days of snow cover. Summers are usually hot, dry, and windy. Temperatures above 100° F. are common.

The topography of the area is rolling and the soil becomes progressively shallower from the highest levels down toward the brows of the hills (Albertson, 1937). The vegetation consists mainly of Bouteloua gracilis, Bouteloua curtipendula, Buchloe dactyloides, Agropyron smithii, Andropogon gerardi and Andropogon scoparius. In addition to the grasses, forbs occur, some of which are included in this study.

RELATED STUDIES

Very little work has been done on the behavior of plants during winter. Baldwin (1921) stated "that some plants pass winter having a rosette of leaves. Many plants withdraw from above the ground entirely; some by means of roots that contract, drawing below the surface the tender terminal bud that will push up into leaves and flowers in the spring; others like the witch grass living underground stem." Brownell (1926) made photographs of rosettes of aster, common mullein, the fern-like tansy, the tall thistle, sheep sorrel, rattlesnake weed, hawkweed and ground pine. He also remarked that botanical writings pay little attention to winter rosettes and appear to disregard their green beauty in the winter. Palmer (1960) has pointed out the importance of basal rosettes and concluded that basal leaf production may permit the survival of certain plants.

METHODS

Winter behavior of important forbs was studied in the college pasture about two and one-half miles west of Hays, Kansas. The study location included areas of deep heavy soils on the uplands and shallow limestone soils on the hillside. Twenty-five species of forbs were selected and three plants of each species were staked and labelled for observation and study. Observations were also made on other plants of the same species. Observations included appearance, growth development and condition in which the plants spent the winter. Characteristics such as pubescence, leaf shape, color pattern of leaves and stems were also studied. Whenever necessary the underground portion, especially the rhizome, was also studied.

Before the spring season started, examples of all twenty-five species were excavated and placed in the greenhouse to determine how they break dormancy and resume growth. The temperature maintained in the greenhouse was near 70° F.

Field observations were made when possible, but due to snow the intervals were inconstant. Forbs included in the study were as follows:

COMMON NAME	SCIENTIFIC NAME
Stiff leaf goldenrod	Solidago rigida
Resinous skullcap	Scutellaria resinosa
Dotted gayfeather	Liatris punctata
Oval leaf bladderpod	Lesquerella ovalifolia
Black samson	Echinacea angustifolia
Stemless tetraneuris	Tetraneuris stenophylla
Broom snakeweed	Gutierrezia sarothrae
Serrate leaf evening primrose	Oenothera serrulata
Catclaw sensitive brier	Schrankia uncinata
Slender greenthread	Thelesperma gracile
Upright prairie coneflower	Ratibida columnifera

Nineanther dalea	Dalea enneandra
Western ragweed	Ambrosia psilostachya
Wavy leaf thistle	Cirsium undulatum
Baby white aster	Aster arenosus
Fendler's aster	Aster fendleri
Purple poppymallow	Callirhoe involucrata
Tall verbena	Verbena stricta
Stenosiphon	Stenosiphon linifolius
Prairie groundsel	Senecio plattensis
James nailwort	Paronychia jamesii
Maxmilian sunflower	Helianthus maxmiliani
Texas sandwort	Arenaria texana
Woolly loco	Astragalus mollissimus
Carolina anemone	Anemone caroliniana

Nomenclature of forbs, both common and scientific names follows Anderson, 1961.

CLASSIFICATION OF ROSETTES

The word rosette has been defined by several botanists. According to Lawrence (1951), a rosette is an arrangement of leaves radiating from a crown or center and usually at or close to the soil surface as in Taraxacum (dandelion). Dayton (1931) described a rosette as a dense basal cluster of leaves, as in common dandelion, caused by dwarfing of true (leafy) stem and so named because of its resemblance to the petals of a double rose. Webster's New International Dictionary (1937) defines a rosette as a very short internode bearing a cluster of leaves, either on the ground, as in the house leek, dandelion, etc. or at the apex of a caudex, as in many tropical genera. All definitions of the term rosette are quite general and, with the exception of Webster's dictionary, refer only to a basal type. No definitions make any reference to the cluster of green leaves frequently found on old stems. An exhaustive survey of the literature revealed that botanists have given very little attention to the behavior or classification of rosettes.

In this study, rosettes are defined as a cluster of green leaves occurring on any part of the old plant body during winter dormancy. The basal rosette has small green leaves on the basal part of the stem and near the surface of the ground. Usually, in such cases, the old stem is dry and the leaves arise from the crown. However, in some rhizomatous plants like wavy-leaf thistle the rosette may not arise from the old crown but from a rhizome. Resinous skullcap is an example of a typical basal rosette (Fig. I).

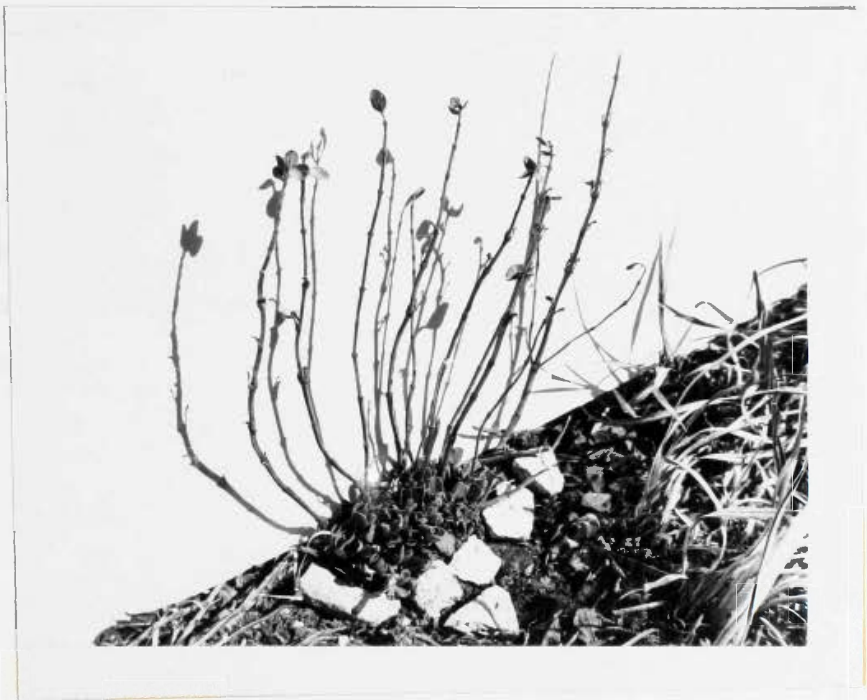

Figure I. Basal rosette of resinous skullcap(*Scutellaria resinosa*). Note cluster of small, oval leaves at base of previous year's stems.

The stem rosette consists of small leaf clusters at the nodes of old stems. Often the old stem is semi-woody in nature and frequently the rosettes are more numerous on the lower part of the stem. However, in some cases, the leaf clusters are found scattered all along the stem. An example of a stem rosette is broom snakeweed (Fig. II).

Terminal rosettes are present at the apex of a stem or branch. Terminal rosettes are also most frequently found on plants with semi-woody stems. This group is characterized by stenosiphon (Fig. III).

Some forbs of the prairie do not produce rosettes and initiate their growth in spring either from crown buds beneath the soil or from rhizomes. An example of a plant with crown buds is blacksamson and a plant with rhizomes is western ragweed.

Figure II. Stem rosette of broom snakeweed (Gutierrezia sarothrae). Note clusters of small green leaves along old stems.

Figure III. Terminal rosette of stenosiphon (Stenosiphon linifolius). Note green leaves at apex of old stem.

RESULTS

The general description of the plants studied was compiled from different sources (Gates, 1931; 1941; Stevens, 1948; Gleason, 1952; Phillips Petroleum Company, 1955-1960). The description also included observations and notes taken in the field and greenhouse.

GENERAL OBSERVATIONS

All 25 plants studied were found in abundance and 18 passed the winter in a rosette form while seven remained completely dormant. Rosettes of wind flower, woolly loco, broom snakeweed, prairie coneflower and prairie ragwort were more abundant than other species studied. Many other forbs, not included in this study, were also observed in the rosette stage.

In most plants old growth of stem and leaves remained intact throughout the winter. Rosette leaves showed some characteristics which were universal in nearly all plants studied. For instance, pubescence seemed to be a common characteristic of rosette leaves. Variation in the degree of pubscence occurred. Glabrous leaves were scarce. Several rosette leaves were found to be tinged with a purple color and many had a greyish cast which may have been partially due to the degree of pubescence. Also, rosette leaves were smaller in size than leaves of a mature plant. As evidenced from the growth of rosettes which were collected from the field and allowed to develop under greenhouse conditions.

In some basal rosettes the lateral spread of leaves on the ground surface was reduced through the winter months, probably due to the covering

of leaves with snow. Older rosette leaves showed yellowing when observed after the snow melted, while younger rosette leaves remained green, healthy and uninjured from freezing.

Buds at the crown of plants were not injured because they were cutinized, suberized, or covered with hairs and bud scales which inhibited rapid freezing and thawing (Daubenmire, 1947).

During winter months no growth of rosettes was observed except during one 15-day period of bright sunny days with relatively high temperatures when slight development in leaves of some rosettes and buds was noticed.

In general, size of rosettes varied somewhat according to the habitat. For example, leaves of the rosette of broom snakeweed were larger on deep mature soils than on shallow, rocky soils.

Out of 25 plants which were brought to the greenhouse, 23 showed rapid growth either from rosettes or crown buds. Spring growth of rosettes started by the end of March in their natural habitats.

Individual Plant Description

Solidago rigida

General Description: Stiff-leaf goldenrod is a perennial forb reproducing by seeds and shoots from heavy rootstocks. It grows to a height of 60 to 120 cm. The stem is coarse, stout, branched slightly at the top and usually occurs in clumps. The leaves are alternate, stiff and thick, greyish hairy with margins that are smooth or with shallowly rounded teeth. The lower leaves have longer petioles than upper ones, and some

of the upper leaves may be without petioles. Flowers appear from August to October.

Stiff-leaf goldenrod grows on a variety of prairie soils throughout the eastern half of the United States, but is usually found in dry, gravelly open places of woods and prairies.

Winter Activity: The stiff-leaved goldenrod occurred as two forms during the winter: (1) some plants had basal rosettes and (2) others were completely dry and did not have any green leaves. Only one of the three staked plants showed rosette growth and observations of other plants showed about the same proportion of rosettes. In the fall a cluster of upright, long stemmed, basal leaves appear at the base of the plant, and sometimes these large green leaves are 30 or more cm. long and remain throughout the winter, thus contributing needed food to the plant for early spring growth (Phillips Petroleum Company, 1955-1960). The large winter leaves helps to identify this sturdy prairie plant.

In general, the old growth was dried and usually the stem and leaves were found intact. The basal rosette consisted of oval shaped leaves arising from the base of the plant. The leaves varied in length from three to six cm. and were purplish green in color. The older leaves of the rosette were injured by freezing and thus only the younger and smaller leaves remained later in the season. Buds about two to three mm. in length, were present at the crown of the plant below the soil surface. Spring growth began about the third week of April with the development of new shoots and elongation of the central stem.

Scutellaria resinosa

General Description: Resinous skullcap is a perennial forb. The stem arises from a woody crown, and is branched. Leaves are ovate to elliptic, finely greyish pubescent. Flowers are solitary in the leaf axils, blue or purplish in color, and appear in summer.

Winter Activity: Resinous skullcap had a basal rosette which consisted of dense foliage of small oval rosette leaves lying at the base of last year's stems (Fig. I). Old leaves of the previous year had all fallen late in the fall. The rosette leaf measured two-tenth to one cm. in length and about one mm. in width. The number of leaves per rosette varied from six to ten. Drying of rosette leaves was not observed; however, the color varied from light to dark green. The small dark green leaves were pubescent over the entire surface.

In the greenhouse the plant grew well for a few days but dried later, partially because of poor drainage. Spring growth began with elongation and widening of the leaves during the fourth week of March. Shortly after, the stem bearing growing leaves began elongating.

Liatris punctata

General Description: Dotted gayfeather is a perennial forb which grows to a height of 30 to 60 cm., reproduces by seed, and has a thick and short rootstock. This plant may be identified by small dots or glands on harsh narrow leaves five to fifteen cm. long. The plant produces flowers from August to October. Flower heads are crowded into a dense spike at the end of the stem, each separated from the one above by a small leaf or bract.

Dotted gayfeather is very drought resistant and is found on the open plains and prairies from Saskatchwan to Texas and New Mexico.

Winter Activity: Dotted gayfeather had no rosettes. The old stem remained intact but the leaves fell on the ground. Plants possessed buds at the crown of the stem though these buds were very small, only about two-tenth to one-half cm. long. Buds did not develop rapidly even after blazing star was placed in the greenhouse.

Spring growth began when the crown bud beneath the ground began pushing out leaf shoots during the second week of April.

Lesquerella ovalifolia

General Description: Oval leaf bladderpod is a herbaceous, drought-resistant perennial with tufted erect stems and grows to a height of 12 cm. or more. Stem and leaves are beset with a stellate canescent pubescence. Leaves are tufted, obovate to oval, tapering to an elongate petiole. Yellow flowers are borne on a short raceme and appear from April to June. It is found on dry rocky soil of the high plains.

Winter Activity: Color of the plant during the winter months was a greyish green (Fig. IV). Rosettes were present at the terminal point of each branch of the stem. Rosettes were difficult to see because they were covered by old dry leaves of the previous year's growth. Almost all the old and dried leaves remained intact. Green leaves in each rosette varied from four to nine in number with an average length of one and three-tenths cm. Leaves were densely stellate, canescent and remained healthy and green. The oval-shaped leaves were grey on the dorsal and green on the ventral surface. The leaves were densely hairy, the short fine hairs being in star shaped clumps covering both leaf surfaces.

Figure IV. Terminal rosette of oval leaf bladderpod (Lesquerella ovalifolia).

Spring growth began during the second week of April. The leaf branches began elongating bearing the old rosette leaves which had begun to get longer and narrower. Several of the old rosette leaves dried in the spring.

Echinacea angustifolia

General Description: Blacksamson is a deep rooted, herbaceous perennial forb which grows from 30 to 75 cm. tall. It bears long, ascending, lanceolate leaves clustered near the base and reproduces by seeds and crown buds. Flowers are produced from June to July.

Black samson grows abundantly on all prairie soils throughout the United States, but prefers hillside locations.

Winter Activity: The plant became dry in the fall and the old stem turned a brownish black color. In some plants, the stem was broken. At the base of several plants, the removal of old and dry leaves, revealed crown buds. The purple buds were protected by the old growth. The plant in the greenhouse produced a new shoot from the crown bud. The first leaf shoots arising from the crown bud began pushing through the ground during the first week of April.

Tetraneuris stenophylla

General Description: Stemless tetraneuris is a herbaceous perennial forb with a slender tap root. Leaves are strongly punctate on the upper surface. Flowers are pale yellow fading to white and appear from May to June.

Winter Activity: The plant is semi-woody and appeared to be greyish in color and dry during winter months, though it had rosettes at the apex

of each branch. Each rosette consisted of four to five leaves in a star shaped cluster (Fig. V). Leaves varied from five-tenth to one cm. in length and one to one and one-quarter mm. in width. The linear leaves were nearly glabrous at the tip but became densely pubescent at the base. Tips of the leaves had a purplish tinge. In natural conditions, no growth development was observed during winter months. However, during the first week of April the rosette leaves started elongating. Shortly after, a central stem arose from the terminal rosette.

The rosettes developed rapidly when plants were moved to the greenhouse. Old rosette leaves remained dark green in color while younger leaves were light green.

Gutierrezia sarothrae

General Description: Broom snakeweed is a semi-woody perennial forb. It grows 15 to 45 cm. tall with numerous erect branches growing from a woody base. The leaves are alternate, simple, linear, and one and two-tenths to three and seven-tenths cm. long. The yellow, small flowers appear in bunches from July to September.

Broom snakeweed is native from Canada to Texas and west to California. It grows on a wide range of soils except the saline soils. Although widely distributed it is usually most abundant in localities with poorly developed soil and on overgrazed ranges.

Winter Activity: The old plants of broom snakeweed dried partially and turned brown in the fall but on the stems were present many rosettes which remained green throughout the winter. The uppermost portion of the old stem, especially the flowering stalk, was almost completely dry. The rosettes were borne on the stem alternately and were more concentrated

Figure V. Terminal rosette of stemless tetraneuris (Tetraneuris stenophylla). Note cluster of green leaves at apex of old stems.

on the lower half of the plant. Small clumps of green, oval-shaped leaves about one mm. long grew in the axil of the previous year's leaves along the old stems (Fig. II). Eight to twelve leaves per clump were found though the number varied considerably. The thick and spongy leaf blades were covered with short, stubby hairs which could not be seen without magnification. The leaves had a dull green color characteristic of many rosette leaves. Spring growth began in the last week of April. The rosette leaves began to elongate and new leaves were produced from the center of the clump.

Oenothera serrulata

General Description: Serrate-leaf evening primrose is a herbaceous perennial, growing to a height of 30 to 60 cm. The stem is simple or branched from the crown above a long, tough tap root. During the second or third season of growth, the stem becomes woody and the plant resembles a small shrub. Leaves are serrated or notched along the margins and are trough-like in appearance. The plant blooms over a long period as the stems elongate, only a few buds opening at a time.

Serrate-leaf evening primrose grows abundantly on plains and prairies throughout the United States. Because of the deep tap root and extensive root system, it is extremely drouth resistant. The plant is more commonly found in gravelly shallow soils.

Winter Activity: Stem rosettes of evening primrose consisted of inconspicuous rose-shaped clusters of leaves growing along the stem of the previous year's growth (Fig. VI). Several rosettes per plant were found. Rosettes were more abundant on the old stems in the fall than they were

Figure VI. Stem rosette of serrate-leaf evening primrose (Oenothera serrulata).

the following spring. The upper portion of the stem was partially dried in all three study plants. The purple-tinged green leaves were densely pubescent and showed slight drying on the margins. Leaves were about five mm. long and two mm. wide. The average number of leaves in each rosette clump was eight and varied from five to twelve.

Under adverse conditions of freezing, several rosettes were killed especially those on the upper portion of the old stem. Two weeks of bright sunny days promoted the development of buds on the old stem but did not develop completely because of recurrence of freezing temperatures.

Observations in the greenhouse showed that each rosette after growing to flowering stage became a branch of the stem with flowers. Under natural conditions in the prairie, the leaf blades began to elongate during the first week of April.

Schrankia uncinata

General Description: Catclaw sensitive brier is a deep-rooted, herbaceous, perennial legume which reproduces from both crown buds and seeds. It grows close to the ground with vine-like stems, and attains a height of about 60 to 90 cm. Leaves are alternate, bipinnately compound and leaflets are small. Another characteristic of the leaves is sensitivity to touch. It blooms from May to September.

Catclaw sensitive brier is found throughout the prairie and grows on a wide variety of soils ranging from deep, fertile soil to shallow outcrops.

Winter Activity: This perennial legume did not have any rosettes, but the stem was found dried above the ground in the fall. No sign of emerging shoot was noticed in the underground portion. In the greenhouse shoots arising from the crown were observed at the beginning of April.

Thelesperma gracile

General Description: Slender greenthread is a perennial forb growing to a height of 30 to 90 cm. Leaves are opposite and bipinnately divided into linear segments. It flowers from May to August and bears yellow to brownish flowers. The plant is adapted to a dry soil and climate, and is commonly found on plains, prairies, and roadsides.

Winter Activity: Evidence of a winter rosette on slender greenthread was not always apparent. In some plants a few leaf clusters were attached to the side of the stem at the base of the previous year's growth. Some plants did not have any rosettes but on others the small shoots varied from 1.5 to 2.5 cm. long. The linear leaves of the basal growth had a dull green color and a very slight pubescence. Basal growth in some plants become dry early in the season.

During the second week of April the rosette leaves began elongating and during the third week a central stem began arising from the center of the basal growth.

Ratibida columnifera

General Description: Upright prairie coneflower is a herbaceous perennial and reproduces by seeds and short underground stems. The plant grows from 30 to 60 cm. high and is characterized by slender hairy stems.

Leaves are deeply pinnately divided into very narrow segments, and decrease greatly in size toward the apex of the stem. Bright yellow flowers are produced from May to August.

This forb grows on a variety of soils and is found in meadows, protected areas, slopes and hillsides throughout the prairies of the United States.

Winter Activity: The rosette of upright prairie coneflower consisted of a basal growth of leaves (Fig. VII). These arose from basal parts of the old stem and varied in number. Great variation in the development of leaves was noticed. When observations were taken early in November and December, the rosette had well-developed leaves but later in winter the older leaves were injured by snow and cold and finally were killed thus reducing the lateral spread of the rosette. Leaves varied in length from one to four cm. Leaves as small as one cm. were also present in the rosettes of some plants. Leaves were nearly oval to linear in shape, slightly pubescent at the tip, and heavily pubescent at the base. Plants moved to the greenhouse grew rapidly and the shape of the leaves changed to resemble those of a mature plant. Spring growth in the field started in the last week of March by elongation of the leaves and leaf branches.

Dalea enneandra

General Description: Nineanther dalea is a smooth perennial forb, with an erect, slender stem and a deep strong root. The stem is unbranched and naked below but with several to many tenuous and well-foliated branches and branchlets above, which terminate with thin, loose flowering spikes.

Figure VII. Basal rosette of upright prairie coneflower (Ratibida columnifera).

Leaves are small, pinnately compound and strongly punctate. White flowers are produced from June to August. The plant is found in prairies and plains.

Winter Activity: Nineanther dalea remained dry throughout the winter months. No crown bud or rhizome was observed under the surface of the ground. Spring growth had not started by the last week of April when this study was terminated.

Ambrosia psilostachya

General Description: Western ragweed is a perennial and reproduces by seeds and rhizomes. The stem is erect, branched and grows 30 to 60 cm. in height. Leaves are short petioled, alternate, or opposite with very deep lobes and rough surfaces. The plant flowers from June to October with two kinds of small, green flowers--male and female.

Western ragweed grows on a wide variety of soils throughout the United States, but is more abundant on the plains and the prairie of the midwest.

Winter Activity: The plant remained dry above the ground with old leaves intact but no rosettes evident. In the greenhouse several rhizomes produced new plants. An exposed root which had rhizome buds also produced new plants. In the field spring growth did not begin during the course of this study.

Cirsium undulatum

General Description: Wavy-leaf thistle is a coarse, stiff ascending, spine covered, rhizomatous perennial. The plant is clothed with matted

white hairs which are especially dense on the under surface of the leaves. Leaves are alternate, simple, prickly and have distinctly wavy margins. Wavy-leaf thistle blooms from June to August and is commonly found in prairies and plains, pastures, and waste places.

Winter Activity: The forb lived winter as basal rosettes; however, plants also were observed which had no rosettes. Leaves were densely white tomentose throughout and slightly lobed with several strong prickles arising at nearly every lobe (Fig. VIII). Number of leaves per rosette varied from four to six. Average length of the leaf was four and one-half cm. and the width two cm. The old stem was found intact in some plants but broken in others. The leaves began to elongate during the last week of March and later became much more heavily serrated taking on a wavy appearance.

Aster arenosus

General Description: Baby white aster is a perennial with a cespitose caudex. The stem grows about one dm. high, with appressed stiff hairs. Leaves are linear-oblanciolate and appressed with hispid-ciliate hairs. It flowers from June to September.

Winter Activity: The baby white aster had a winter growth which was classified as a basal rosette. Each rosette clump had 10 to 15 leaves and was growing from the old stems at the base of the plant. Leaves were densely pubescent with long heavy hairs on the margin and on the dorsal surface but were nearly glabrous on the ventral surface. Leaves averaged four mm. long and one mm. wide. Leaves began elongating on developing stems of the old rosette during the first week of April.

Figure VIII. Basal rosette of wavy-leaf thistle (Cirsium undulatum).

Aster fendleri

General Description: Fendler's aster is a perennial forb with a root-stock or caudex. The stem is one to three dm. high, stiff and sparingly hirsutulous. Leaves are linear and about two to three cm. long. It is found on plains and sandhills.

Winter Activity: The plant appeared to be greyish and dry but rosettes of linear leaves were present at the terminal of each branchlet of the stem. Rosettes were surrounded and nearly hidden by dry leaves of the previous year. The color of the rosette leaves was purplish near the base. Old leaves of the previous year's growth were found intact early in spring but later most of them fell off.

Spring growth began in the first week of April with the elongation of a new stem in the center of the rosette and growing away from the old purple rosette leaves.

Callirhoe involucrata

General Description: Purple poppy mallow is a perennial with thickened deep tap root. Stems are procumbent on the ground extending in all directions from the crown or sometimes ascending. Leaves are orbicular, cordate, palmately cleft, lobed and toothed. Plants flower from April to August and are most commonly found in prairies and plains on dry soil.

Winter Activity: Purple poppy mallow had a basal rosette (Fig. IX). When the three study plants were observed first in the fall, all had many leaves widely spreading on the ground. As plants were subjected to freezing and thawing the older leaves were injured. In early winter

Figure IX. Basal rosette of purple poppy mallow (Callirhoe involucrata).

leaves appeared to be yellowish and finally dried. Hence, lateral spread was considerably reduced. Younger leaves in the center remained green and healthy. Leaves were palmately parted and the lower surface was slightly rougher than the upper surface. The leaves were pubescent on the lower surface and the upper surface was glabrous to partially pubescent. Margins were hairy.

Spring growth started during the last week of March and several new shoots arose from the crown.

Verbena stricta

General Description: Tall verbena is a perennial forb reproducing by seed and shoot rhizomes. The plant grows 30 to 120 cm. tall and the stem is erect and branched above. Leaves are simple, opposite and sessile, coarsely toothed and hairy. Tall verbena blooms from June to September and produces purple flowers which are borne in long spikes. The forb is very common in the Mississippi Valley and is usually found scattered but not abundant in native western Kansas pastures.

Winter Activity: Tall verbena had no winter rosette but the plants possessed buds on the crown which remained dormant underground during winter. When plants were allowed to grow in the greenhouse the crown buds produced new shoots.

Stenosiphon linifolius

General Description: Stenosiphon is a slender, smooth, herbaceous and short-lived perennial with wiry branches near the top, becoming 150 cm. high. Leaves are lanceolate with broadened base, somewhat clasping the

stem, but are narrowly linear-lanceolate. Flowers are white and appear from July to September.

Stenosiphon is found in dry prairies, plains, and rocky hills and is restricted to a strip of territory extending from Nebraska south through Kansas, Colorado, Oklahoma, Texas, and into Mexico.

Winter Activity: Stenosiphon had a single terminal rosette growing at the tip of the old stem (Fig. III). Each group of rosette leaves numbered from four to eight and varied from one and one-half cm. to two and one-half cm. long. In addition to the terminal rosette, there were occasionally some clusters of leaves growing along the stem. Terminal leaves were long and narrow while the leaves growing along the stem, when they occurred, were slightly oval in shape. Practically all leaves had a purple streak around the margin and along the mid rib. The margin was entire with very short bristly hairs. The lower and upper surfaces of the leaves were glabrous. New leaves arising from the rosette were more glabrous under greenhouse conditions. Drying of some leaves, especially the margins, was noticed.

Growth started with a slight elongation of the terminal leaves and an initiation of a central stalk from the terminal rosette during the first week of April.

Senecio plattensis

General Description: Prairie grounsel is a perennial forb with a short caudex and fibrous roots, which reproduces by seeds. The plant grows from 50 to 60 cm. high. Leaves are alternate, simple and lobed. Basal leaves are narrowly or broadly elliptic or ovate and petioled. Yellow flowers are borne in a composite head and appear from May to June.

Winter Activity: A rosette of leaves is formed during late summer with a conspicuous purple lower surface (Dwyer, 1958). This forb had basal rosettes with three to six leaves in each rosette. Leaves were oval-shaped, petioled, were slightly serrate on the margin, and were green on the dorsal side with a deep tinge of purple on the ventral side. Both the surfaces of the leaf blade were slightly pubescent becoming much more densely hairy at the base and on the petioles. The leaves of the plants, instead of lying flat on the ground, were elevated at about a 45 degree angle from the ground (Fig. X). The leaves varied from one and one-half to six cm. long.

Growth began about the first week of April with a slight elongation of the leaves and a rapid growth of the central stem.

Paronychia jamesii

General Description: James nailwort is a herbaceous perennial branching at the base. The stem is erect and eight to 25 cm. high. Leaves are linear and about seven-tenths to two cm. long. Its flowers appear from July to October.

Winter Activity: James nailwort had basal rosettes with four to six leaves growing out from between papery bracts at the base of the old stem (Fig. XI). The linear leaves were pubescent with short bristly hairs and a toothed margin. Leaves averaged from eight-tenths to one and four-tenths cm. in length and two-tenths mm. in width. The rosette leaves remained green and healthy throughout the winter.

During the last week of March the leaves and the central stem of the rosette clump began elongating slowly.

Figure X. Basal rosette of prairie groundsel (Senecio plattensis).

Figure XI. Basal rosette of James nailwort (Paronychia jamesii). Note sparse linear leaves at base of previous year's stem.

Helianthus maxmiliani

General Description: Maxmilian sunflower is a perennial forb which spreads by seed as well as by underground fleshy roots and thickened rootstocks. It grows upright, 90 to 180 cm. tall, singly or in close clusters with yellow flowers appearing from July to September. Sunflower leaves are long and narrow, trough-shaped, which taper at both ends. The upper surface is usually rough.

Maxmilian sunflower is found throughout the plains and eastern prairies of the United States, growing on a variety of sites east of the 25-inch rainfall belt but more prominent on heavier soils.

Winter Activity: Maxmilian sunflower had no rosettes but did have rhizomes which were found developing during fall. No further development was noticed during the winter months (Fig. XII). In the greenhouse rhizomes grew very rapidly and produced new plants. No spring growth was observed during the study period.

Arenaria texana

General Description: Texas sandwort is a perennial forb. The stem is erect and five to 20 cm. tall and usually the lower third is leafy. Leaves are subulate, stiff and about six to twelve mm. long. The plant flowers from May to July and is found on dry and rocky soils.

Winter Activity: The general appearance of the plant was yellowish green. Rosettes were borne at each node along the entire stem and on the branches (Fig. XIII). Ordinarily, there were two rosettes at one node attached oppositely. Rosettes were classified as stem rosettes. Small

Figure XII. Rhizomes of Maxmilian sunflower (Helianthus maxmiliana).

Figure XIII. Stem rosettes of Texas sandwort (Arenaria texana). Note dark areas on stem which represent small green leaves of rosettes almost hidden by last year's material.

green leaves about three mm. or more long occurred in clumps of five to ten leaves per clump. The linear glabrous leaves were dry and spongy. Detection of the green leaves on the plant was difficult because dry foliage of the previous year remained. In some plants more dense rosettes were observed at the base. Leaves at the base of the old stems appeared to have a better color and appeared healthier probably because of protection from the snow. Spring growth of rosette leaves began the first week of April and the stems started growing out of the old rosette clumps.

Astragalus mollissimus

General Description: Woolly loco is a perennial poisonous legume. It is low growing, stout, and herbaceous, growing to 20 to 45 cm. tall. The root system is deep and woody. Leaves are pinnately compound with each leaf having 8 to 12 leaflets. The leaves lie close to the ground. Stems and leaves are covered with long, dense, whitish appressed hairs forming a woolly covering. Purple flowers appear from May to July.

Woolly loco is found growing from Texas to South Dakota and west to Colorado but is most abundant in the Panhandle of Texas and adjacent areas.

Winter Activity: The rosette of woolly loco spreads on the ground and hence is classified as a basal rosette. Actually the rosette is a reduced version of the previous year's plant (Fig. XIV). The older leaves which were long and had a greater lateral spread were injured to some extent in the fall and showed curling and drying. Leaves in the center were small and remained green and healthy and thus became the winter rosettes.

Figure XIV. Basal rosette of woolly loco (Astragalus mollissimus).

Below the older leaves some young shoots were observed which were not injured from freezing. The longest and shortest leaves were 16 and five cm., respectively. Rosette leaves were covered with dense, whitish hairs which produced a woolly, silver appearance. Spring growth started the last week of March by elongation of the small shoots which were dormant during winter months.

Anemone caroliniana

General Description: Carolina anemone is a perennial herb and reproduces from a bulbous rhizome. The plant grows 10 to 25 cm. tall. The stem is erect and commonly glabrous toward the base. Basal leaves are deeply three-parted, the segments deeply and irregularly incised into few or several acute divisions. It is found on dry prairies and barren lands.
Winter Activity: In most rosettes of this plant there was a single leaf which was deeply lobed into three parted segments and about one and one-half to three and one-half cm. long (Fig. XV). The petiole above ground was purplish green and the lower surface of the leaf, especially the center, was tinged with purple. The margin of the leaf also showed some purple color while the upper surface remained green. The rosette leaf was held two to three cm. above ground by the petiole. Out of the three study plants two rosettes became almost dry in March. Observation of the other plants of the same species also showed that freezing and thawing killed tissues of some plants.

Figure XV. Basal rosette of Carolina anemone (Anemone caroliniana).

DISCUSSION AND SUMMARY

Plants have different ways of surviving the unfavorable seasons of the year. When the days become shorter in the late summer and fall, the growth habits of many plants change. This is true with many perennial plants of the prairie. Such a change in habit may be caused by low temperatures. The low temperatures of winter slow down the physiological processes which were so active at other seasons. Most of the above ground parts of plants either die or become dormant during winter but some plants develop clumps of green leaves either at the base, on the old stem or at the terminal point of the plant. Such a form of growth is called a rosette.

Not all plants possess rosettes. Some die completely back to the crown in winter and others which have rhizomes and do not resume growth until the warm days of spring. Evidently plants under study can be grouped into two catagories--those having rosettes and those without rosettes.

Rosettes have been classified in this study according to their position in relation to the old plant (previous year's growth). These occurring at the base of the old plant were called basal rosettes; those found along old stems were stem rosettes; and those growing at the tip of old stems were called terminal rosettes.

Twenty five prairie forbs were studied and 18 were found to have some type of rosette growth. Eleven plants had basal, four had terminal and three had stem rosettes. The other seven plants had developed

protected crown buds or possessed rhizomes, which remained dormant during winter. Plants having rosettes were as follows:

BASAL ROSETTES	STEM ROSETTES	TERMINAL ROSETTES
Solidago rigida	Gutierrezia sarothrae	Lesquerella ovalifolia
Callirhoe involucrata	Oenothera serrulata	Stanosiphon linifolius
Ratibida columnifera	Arenaria texana	Tetraneuris stenophylla
Astragalus mollissimus		Aster fendleri
Anemone caroliniana		
Senecio plattensis		
Scutellaria resinosa		
Cirsium undulatum		
Thelesperma gracile		
Paronychia jamesii		
Aster arenosus		

Rosettes varied considerably in size and shape and leaves of many rosettes were completely different from leaves found on the plant during the growing season. The size of rosettes varied from one habitat to another. In places where the soil is deep and fertile the rosette might grow better than one growing in a shallow rocky soil. Therefore, measurements taken in the present study can only be considered average for a particular area. No doubt considerable variation would also be found when comparing size during different years.

The principle purpose of this study was to identify and classify some of the rosette forms in the prairie. It is hoped this pilot study will encourage others to continue study of these and other forms and that eventually rosettes will be sufficiently well described so that they can be recognized as readily as they are in summer. Many other studies might be suggested dealing with morphology, anatomy and physiology of rosettes. Some questions that might serve as themes of future studies are (1) Why do rosettes form? (2) Are rosette leaves different morphologically from normal leaves? (3) Are rosette leaves different anatomically from normal leaves? (4) What is the extent of photosynthetic activity in rosette leaves?

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